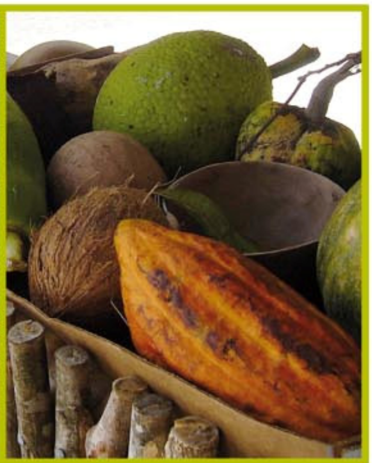
This project is funded by the European Union



# Diversification of the Agro-Economy of St. Lucia – Identification of Cash Crops and Service Plants for Cultivation Systems Adapted to the Economic Needs and Pedoclimatic Conditions.

## A Desktop Study

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AGiL
Banana Commercialisation and Agricultural Diversification in St. Lucia

**Hamburg University of Applied Sciences, Hamburg/Germany &**
**Sir Arthur Lewis Community College (SALCC), Castries/St. Lucia**
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# Foreword

This study was prepared in the context of the EU project "Banana Commercialisation and Agriculture Diversification in St. Lucia" (AGIL Project), performed by the Hamburg University of Applied Sciences, Germany, and the Sir Arthur Lewis Community College (SALCC), St. Lucia, and funded by the budget line B7-8710 21 03 18/856 and as part of the programme SLU SFA 2004 CFP 01.

The project consists of a set of initiatives related to human resource development and training in the agriculture sector, in order to assist the on-going efforts towards improving economic growth in St. Lucia. In methodological terms, the project includes an assessment of the current state-of-affairs and training and information needs seen in the agricultural sector, combined with a comprehensive awareness-raising, training and consulting programme to raise its productivity. The project also acknowledges the importance of non-traditional agricultural commodities, such as breadfruit, hot pepper, and mangoes, plantains, sweet potatoes and passion fruit as some of the means to achieve not only greater agricultural crop diversification, but also diversification of export crops into food crops. The set of actions envisaged as part of this project include consultancy, training workshops and seminars on the one hand, complemented by coaching within businesses as well as a business-friendly system of advice on the other hand, which caters for the needs of small enterprises and the realities of small farmers.

In the context of the project "Banana Commercialisation and Agriculture Diversification in St. Lucia", an analysis of the cash crops and service plants for cultivation systems adapted to the economic needs and pedoclimatic conditions was performed. The rationale for this study is based on the fact that successful attempts to promote agriculture diversification in St. Lucia can only succeed, if they are based on sound scientific information on its soil and the soil's capacity to sustain different produce. In this context, it is important to provide a critical analysis of the extent to which economic needs match pedoclimatic conditions, goals which have been achieved by means of the present study.

Thanks are due to the office of the National Authorising Officer of St. Lucia, the Ministry of Agriculture and the colleagues at the Sir Arthur Lewis Community College for their inputs in preparing this report and for the support offered to the project. Thanks are also due to Dr. Christoph Reisdorff for the research which has led to this report. It is hoped this document will provide a basis upon which the adaptation of more efficient productions systems related to sustainable banana production are encouraged and best practices in respect of agricultural diversification and fair trade can be fostered.

Hamburg/Germany, October 2008

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## Executive Summary

This report is intended to contribute to a conceptual design of use systems adapted to the local pedoclimatic and economic conditions of the island of St. Lucia, by paying a special attention to its carrying capacity and the projected climate change impacts on the agricultural sector. Various species of crop plants are considered with respect to economic potentials, agro-ecological profiles, ecological service functions, and cultivation practices. On the basis of agro-ecological zoning models, which have already been established for St. Lucia, this study aims to contribute to a sustainable land use policy by helping to identify best suited plant combinations to particular categories of land utilization types. The main findings of the study can be summarised as follows:

a) The first priority for a sustainable development of the agricultural sector of St. Lucia is the establishment of agroforestry systems especially on hillsides where currently mainly banana is produced.
b) In the case of St. Lucia there are a few degrees of freedom regarding the selection of potential crop plants which might be promising constituents of agro-ecosystems. For the export based agro-economy of St. Lucia the potential economic value of a crop is as vital as its ecological value, because the limitations in arable land forces people to grow crops with high cash yields per area.
c The survival of most agrarian production units depends on the development of productive and economically attractive agroforestry systems.
d) In the face of climate change, it might be necessary to slightly revise the land utilization type categories, taking into account the potential positive influence of the specific soil cover crops on soil erodibility.
e) The ecological functioning of agroforestry systems towards conservation and improvement of fragile soils depends to a considerable part on the presence of soil cover crops which add erosion-reducing properties to the system which are not provided by the tree canopy. The systematic adoption of soil covering crops has not as yet been fully considered in St. Lucia.
f) In the present study, 13 potential cover crops have been identified to be potentially suitable for St. Lucia with regard to the ecological service functions needed. These plants would need to be studied in trials under the pedoclimatic conditions of St. Lucia.
g) Two cash crops have been identified to play a potential key role with respect to both economic and ecological requirements: sweet potatoes and papaya, which may be considered as functional key elements for the early stages of agroforestry systems which may be installed on former banana plantations.
h) One of the plants with the highest economic potential for export and with certain ecologically valuable features is considered to be the peach palm, which can be used for fruit production, for local consumption or for the production of heart-of-palm for both local and export markets.

The revenue from export crops which are currently cultivated on St. Lucia could probably be increased by fair-trade, bio-certification (e.g. banana, pepper, ginger), by quality improvement (banana, cocoa) and/or by the development of a small local food industry ful-

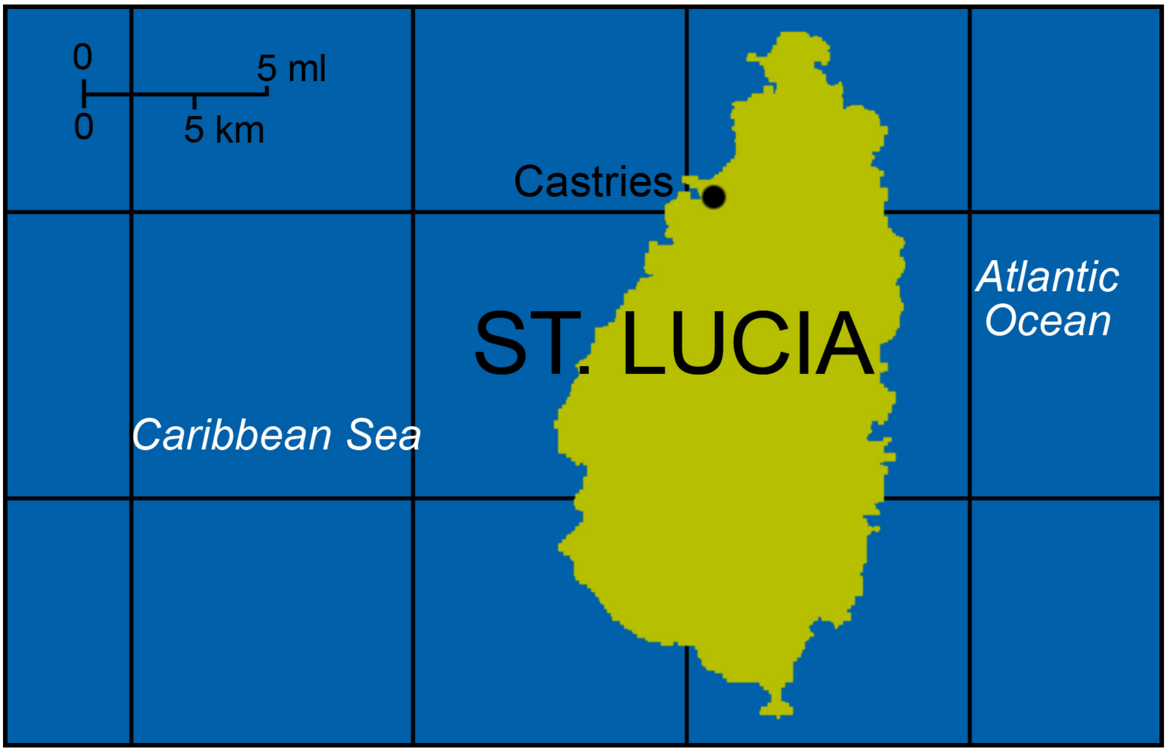
filling EU standards. Juices from exotic fruits, in particular, might have growth potential in the bio sector of the European food market.

Furthermore, it is felt that the local food production must be improved in order to relieve St. Lucia's trade balance which suffers from growing imports of food stuffs. Thus, at least two types of crops may be dealt with: potential cash crops for export and food crops for domestic markets. Finally, a main challenge of moving towards an economic and ecological perspective for St. Lucia's agriculture is to find economically valuable cultivation systems which may be developed further whilst retaining the vital ecological functions.

## 1. Introduction

St. Lucia is one of a group of islands known as the Windward Islands. Other islands in the group include Grenada, Martinique and St. Vincent and the Grenadines. The Amerindian Arawak and Carib people were early settlers in St Lucia. They called St Lucia the "Island of the Iguanas" (Iouanalao and Hewanorra). St. Lucia is twenty-eight miles long and thirteen miles wide (Figure 1). The highest point in St Lucia is Mount Gimie (950 m).

Figure 1: Schematic View of the Island of St. Lucia




Source: own illustration

St. Lucia's climate is tropical, although moderated by north east trade winds. The dry season extends from January to April, with a rainy season from May to August. The island is mainly volcanic and mountainous, however there are broad, fertile valleys in places.

The economy of St. Lucia is based on agricultural production mainly of banana and plantains (*Musa paradisiaca*) for export. The area under cultivation which amounted to a total of ca. 26,000 ha in the 1980s is continuously decreasing approaching actually 9,000 ha according to the census of the FAO (FAOSTAT 2008; see Annex 6). The loss of arable land is attributed to soil fertility loss as a consequence of inappropriate land use.

In 2005, agriculture accounted for 4.3% of the total gross domestic product (GDP). The production of bananas occupies about 48% of the arable land. A further 42% of cultivated land is used for the production of coconuts. Indeed coconuts represent the second and pepper (Piper spec.) the third most important export revenue from agricultural production. On the remaining 10% of arable land mainly roots, tubers, vegetables and fruits are grown for domestic markets (St. Lucia Ministry of Agriculture, Forestry and Fisheries 2006; Anonymous 2006). In view of the alarming experiences of the last decade with the destabilizing effects of trade liberalization, devastating plant diseases in banana monocultures, and of unfavourable climatic conditions and weather events especially hurricanes and storms (Anonymous 2006) there is now a consensus among agrarian experts and politicians of St. Lucia that the low agro-diversity results in a high vulnerability of its agro-economy to economical and environmental disturbances.

The prevailing forms of agricultural production cause severe losses of soil fertility (Cox et al. 2006) leading to a continuous increase of degraded farmland in the range of 1,000 to 2,000 ha per annum according to FAO census data (FAOSTAT 2008; see Annex 6). This means a disastrous development regarding the fact that all arable land had already been reclaimed and the remaining high elevation forests are essential for the island's water balance. Thus, "increasing degradation of St. Lucia's watershed areas represents one of the most serious threats to sustainable social and economic growth" (Tulsie et al. 2001, John 2008).

The phenomenon of climate change is expected to potentially increase the vulnerability of the agricultural sector of St. Lucia. The anticipated impacts of sea level rise, increased temperatures, tropical storm activities, and, in particular, changes in the precipitation regime are capable of shifting the island's life zones and changing dramatically the pedoclimatic conditions for agricultural production (Tulsie et al. 2001). Hurricanes such as Lenny and Dean have caused severe damage in St Lucia.

The insights into stabilizing mechanisms of diversity in ecological and economical terms caused agro-economic experts and politicians to make "diversification of agriculture" a central issue of their action plans to combat existing and prospective threats to St. Lucia's agro-economy (St. Lucia Ministry of Agriculture, Forestry and Fisheries 2006; Tulsie et al. 2001). Recently, governmental organisations of St. Lucia encouraged scientific studies dealing with the management of agricultural watersheds (Cox & Madramootoo 1998, Sarangi et al. 2004) and with ecological zoning (Cox 2003, 2004, Isaac & Bourque 2001). These pioneer works and the respective personalized expertises towards an agro-ecological classification and zoning provide the basis for a conceptual design of locally adapted land use systems.

With the knowledge of the pedoclimatic constraints, a strategic approach towards adaptation of land use systems starts with a specification of ecosystem functions which are necessary to conserve or to improve the soil and water status. Crops and service plants must be identified and grouped according to their ecological functions. The resulting short lists of different plant functional types must be intended as a modular system for the design of mixed cultivation systems. When realized, these artificial ecosystems need to be conducted in an adaptive management framework in order to approximate maximum ecological and economical stability (Hobbs & Morton 1999).

## 2. Pedoclimatic Constraints to Agriculture

The soils of St. Lucia are dominated by kaolinite clays in the interior and by montmorillonitic clays in the dryer coastal areas (Cox et al. 2006). They are acidic, relatively low in phosphorus availability, and soil fertility depends on biological factors which is typical for most tropical soils (Gonzales & Zak 1994; detailed studies on soils of St. Lucia: Stark et al. 1966). The climate is tropical maritime with mean annual temperatures ranging between 26°C and 32°C. The mean annual rainfall varies from 1500 mm at the coastal low lands to 3800 mm in the central interior. The bulk of the annual rainfall occurs in the period from July through December due to tropical cyclonic weather systems prevailing during the Atlantic hurricane season. In the dry season the monthly precipitation seldom falls below 50 mm in the plant cultivation regions of the coastal dryer parts in the east, whilst in the central parts it always remains above 100 mm per month even in the driest season (Sarangi et al. 2005).

Erosion and leaching of nutrients and of soil organic matter was becoming a major drawback of agricultural land use practices in recent years, since the banana cultivation was extended to upper catchment areas and steep slopes unsuited to intensive cropping. According to Rojas et al. (1988) 87% of the cropped land of St. Lucia – mainly banana plantations – is situated on fragile soils. Cox (2004) exemplified that for the Talvan catchment of St. Lucia only about 25% of the area is used in a sustainable way. It was shown in another catchment area of St. Lucia that the erosive soil loss from agricultural watersheds grown mainly with banana is about 20 times higher than from forested watersheds (Cox et al. 2006). HTS (1997, cited in Cox et al. 2006) estimated the soil loss rates from hillside monocultures to range between 20 and 100 t $ha^{-1}$ $a^{-1}$ in banana plantations and up to 500 t $ha^{-1}$ $a^{-1}$ in fields of *Colocasia esculenta* (coco-yam). These are rates which by far exceed the tolerable soil loss limit for St. Lucia which is estimated to be 10 t $ha^{-1}$ $a^{-1}$ (Sarangi et al. 2004).

The high erosion rates have been leading to successive losses of soil fertility and to the siltation of drainage systems which are vital for the soundly productive agricultural systems in the valley bottoms (FAO 2001). Accordingly, in *Saint Lucia's Initial National Communication on Climate Change* (Tulsie et al. 2001) factors relevant to erosional processes are listed as major threats to the agricultural sector: the lack of vegetative cover in watersheds, the absence of proper soil conservation practices, inappropriate land use and degradation of soils. These weak points of actual land use practices are not only considered as existing threats, they denote the high vulnerability of the agricultural sector to climate change scenarios for St. Lucia.

In *Saint Lucia's Initial National Communication on Climate Change* (Tulsie et al. 2001) the effect of three climate change scenarios for 2050 with regard to temperature and rainfall climate parameters for St. Lucia are very briefly presented. According to the "high case scenario" (+5°C) tropical storm events increase (+20 events) and annual mean precipitation increases by 20% (Tulsie et al. 2001). Additionally, the distribution pattern of precipitation will probably be altered in a way that drought periods are extended and the surplus of precipitation will come as increased rain intensities. In the “low case scenario” (+1.71°C) tropical storm events decrease (-20) and the annual mean precipitation decreases by some 1.3% (Annex 3). Again, the distribution pattern of precipitation will be altered. According to the “low case scenario” the combination of nearly unaltered precipitation quantity and less storm events is tantamount to higher storm intensities. This means that any climatic change scenario implies a higher intensity and/or quantity of storm events. These alterations will have serious impacts on the agricultural sector if the existing land use pattern are not changed.

A study on storm impacts on agricultural soils in St. Lucia revealed that soil loss is highly correlated with the rainfall intensities and less with rain quantities (Cox et al. 2006). This can be explained by the high impact-energy of the raindrops during heavy rains. When the kinetic energy of raindrops is sufficient to break down superficial soil aggregates the debris moves into macropores and seals them. This leads to a reduced infiltration capacity of the soil which causes higher runoff and, consequently, higher rill and gully erosion. Consequently, the projected higher incidence and/or intensities of storm events in combination with the altered quantity and distribution pattern of the precipitation are expected to increase soil erosion considerably under the current land use pattern.

Thus, cultivation systems intended to allow for a sustainable agricultural production on St. Lucia must be designed for an effective reduction of erodibility. Agroforestry systems are considered to be the only option for sustainable land utilization on the predominating steep terrains of St. Lucia (Cox 2004, Cox et al. 2006). However, the survey on scientific works on land use management in St. Lucia revealed, that cover crops are not yet explicitly considered as functional key elements of agroforestry systems aimed at reducing the risk of erosion in permanent land use systems. This means that one of the first tasks is to identify soil cover crops suitable for the perennial cultivation systems of St. Lucia.

# 3. Plants with Ecological Service Functions

The effect of vegetation cover on soil loss is mostly attributed to the above-ground biomass, whereas in reality reduction of soil loss results from the combined effects of both roots and canopy. Based on a meta-analysis of Gyssels et al. (2005) it can be concluded that vegetation cover is the decisive vegetation parameter for splash and interrill erosion. For rill, sheet and ephemeral gully erosion plant roots are at least as important as the canopy (Gyssels et al. 2005).

Very recently it was shown that the erosion-reducing potential of plant roots depends on root density and diameter: at root diameters > 5 mm the erosion-reducing effects become less pronounced (De Baets et al. 2007). Thus, a key trait of crops, which will effectively reduce rill and sheet erosion, is the formation of a dense system of relative fine roots. These requirements are particularly fulfilled by stoloniferous or clonal growing plants developing adventitious roots on prostrate stems (mostly at leaf nodes) in contact with wet soil. These plant types are capable of forming a dense superficial root mat without generative propagation.

Additionally, roots affect physical soil properties and, hence, indirectly influence soil erosion. Important erodibility-determinants which are influenced by plant roots are: aggregate stability, bulk density, soil texture and infiltration capacity (Gyssels et al. 2005). Potential cover plant species differ considerably with regard to their respective ecological functions. For instance, Obi (1999) found under humid conditions with bimodal precipitation patterns that two leguminous cover crops were capable of increasing the infiltration capacity of a degraded soil 4 to 6 fold, whilst the effect of "promising" grass cover crops was negligible. In part it can be generalized, that the stability of bio-pores formed by roots depends on the C/N ratio of the plant material and on the root size (Barber & Navarro 1994): Higher C/N ratios of the plant material slow down the decomposition rates, and tap roots of > 4 mm improve the soil hydraulic conductivity. However, comparative studies on erosion-reducing effects of particular plants' traits under specific pedoclimatic conditions are still rare.

Hence, the cover crops listed below, which are intended as functional elements in agroforestry systems for the different agro-ecological zones of St. Lucia, have not yet been investigated with regard to their actual erosion-reducing capacity, however, they are promising candidates. This primary selection is based on the following criteria: plant ecological requirements (climate and soil), suitability to agroforestry systems (e.g. shade tolerance, compatibility with other species), agronomic criteria (e.g. establishment ease, experiences as far as known), and promising traits with regard to the erosion-reducing capacity (growth habit, root system).

The short list comprises 13 species which are adapted to different tropical to subtropical environments. Beyond their potential qualification as erosion reducing cover crop for St. Lucia's pedoclimatic conditions, the selected species offer some general advantages: they are leguminous herbs which are capable of forming nodules with nitrogen fixing bacteria; all are proven as forage for livestock; the stoloniferous or clonal growth habit of most candidates allows for spreading even over very heterogeneous and problematic soil patches. A very important criterion for further decisions is the question of whether an individual cover crop is already naturalized in St. Lucia or not. In the latter case the neophytic weed potential must be carefully considered.

As a next step, it needs to be checked with local agronomic and land use authorities in which particular ecological zones, soils, slope range and land use systems a particular cover crop should be tested. After having identified promising lines and cultivars of selected individual species, trials should be realized as on farm experiments with frequent monitoring of establishment, biomass dynamics above and below ground, phenology with respect to seasonality, soil erodibility, etc. Finally a well structuralized and understandable management guide for each cover crop must be developed encouraging farmers to adopt particular cover crops or mixtures in their land use systems.

Table 1: Short List of Potential Cover Crops for Agroforestry Systems

**Species name:** *Aeschynomene villosa* (hairy jointvetch).
**Origin:** Meso- Southamerica (Mexico-Bolivia).
**Habit:** sub-shrub, prostrate - weakly erect; annual or weakly perennial
**Climate:** 800-1500 (460-2400 ); medium drought tolerance
**Soil:** fertility, pH 4.5-8.5 (6-6.5); Al-tolerance.
**Weed potential:** low
**Experiences in agroforestry:** yes
**Strengths:** good seed yields
**Limitations:** excessive water use when in full foliage;
**Remarks:** tolerates water logging; potential cover crop for gully erosion sites

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**Species name:** *Arachis pintoi* (pinto peanut).
**Origin:** Neotropics (Bahia, Goiás, Minas Gerais).
**Habit:** stoloniferous herb, initially prostrate, becoming ascendent (<50 cm); taproot; perennial
**Climate:** 1500-2000 (1000-2000); high drought tolerance (up to 4 dry months)
**Soil:** low-moderate fertility, pH 5.4-7.2 (4.5-7.2); high Al-tolerance.
**Cultivation needs:** moderate - high
**Weed potential:** low-moderate (difficult to eradicate)
**Experiences in agroforestry:** yes
**Strengths:** tolerance to drought and low fertility; persistency; compatibility
**Limitations:** slow establishment, attracts rodents
**Remarks:** good information status; suitable to nearly all life zones of St. Lucia

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**Species name:** *Calopogonium caeruleum* (bejuco culebra, bejuco de lavar, canela-araquan, chorreque).
**Origin:** tropical America, from Mexico and the Caribbean islands to northern Argentina.
**Habit:** twining, perennial, stems up to several metres long, becoming woody with age, rooting at nodes when in contact with moist soil; perennial
**Climate:** 1000-3000 mm; medium drought tolerance
**Soil:** wide range of soil fertility, pH 4.0 (lower limit); moderate Al-tolerance.
**Cultivation needs:** moderate - high
**Weed potential:** considerable
**Experiences in agroforestry:** yes
**Strengths:** High DM production. Excellent cover crop in humid-tropical tree plantations. Can be established from seed or cuttings. One of the most shade tolerant tropical legumes.
**Limitations:** Slow to establish. Weed potential.
**Remarks:** proven mixture with one or more of the species *C. mucunoides, Centrosema molle, Pueraria phaseoloides* and *Desmodium ovalifolium*. Naturalized in St. Lucia? If not, maybe weed potential too high?

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**Species name:** *Calopogonium mucunoides* (calapo, calopo, wild ground nut).
**Origin:** Tropical America.
**Habit:** creeping, twining or trailing, perennial herb, up to several metres long, forming a tangled mass of foliage 30-50 cm thick perennial.
**Climate:** >1500 mm (with 1000mm as annual habit); low drought tolerance
**Soil:** wide range of soils fertility, pH 4.5 - 5.0; high Al-tolerance.
**Cultivation needs:** moderate
**Weed potential:** moderate
**Experiences in agroforestry:** yes
**Strengths:** high pioneer capacity; wide edaphic adaptation
**Limitations:** weed potential; intolerant to regular cutting; poor tolerance to heavy shade
**Remarks:** mixture with one or more of the species *C. caeruleum, Pueraria phaseoloides, Centrosema molle*, and *Desmodium ovalifolium*. Suited to the higher elevated life zones of St. Lucia (subtropical wet forest, subtropical rain forest)

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## Table 1: Short List of Potential Cover Crops for Agroforestry Systems *continued*

**Species name:** *Canavalia ensiformis* (jackbean, pois sabre, haba de burro).
**Origin:** tropical America from southern USA to Central and South America, West Indies
**Habit:** annual herb, vine
**Climate:** wide range of climates; medium drought tolerance
**Soil:** low fertility, pH 4.5 - 8
**Cultivation needs:** high
**Weed potential:** low
**Experiences in agroforestry:** yes
**Strengths:** very successful in comparison trials of annual cover crops. Agricultural experiences. **Naturalized in St- Lucia:** (?).
**Limitations:** annual, no clonal growth
**Remarks:** good information status; high capacity to improve degraded soils but not on steep slopes.

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**Species name:** Centrosema pubescens (C. molle) (centro).
**Origin:** Mesoamerica-Mexico.
**Habit:** Trailing-climbing herb with strong tendency to root at nodes of trailing stems. perennial
**Climate:** >2000 mm; subhumid – humid tropics; low drought tolerance
**Soil:** moderate soil fertility; Non-Mexican germplasm in general better adapted to lesser fertile soils than "common centro" (Centrosema molle?), Non-Mexican germplasm in general better adapted to acid than "common centro" (Centrosema molle?).
**Cultivation needs:** medium
**Weed potential:** low
**Experiences in agroforestry:** yes
**Strengths:** tolerance to lower temperatures; strong tendency of rooting at nodes.
**Limitations:** Low seed production; slow to establish
**Remarks:** suitable to the higher elevated life zones of St. Lucia (subtropical wet forest, subtropical rain forest)?

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**Species name:** Centrosema macrocarpum.
**Origin:** Meso- and South-America
**Habit:** trailing perennial herb with slender stems, rooting at the nodes (some genotypes!). Tap-rooted
**Climate:** Humid to sub-humid, >1000 mm; high drought tolerance once established
**Soil:** low- to medium-fertility. Tolerates very acid conditions; high Al tolerance
**Cultivation needs:** low
**Weed potential:** none
**Experiences in agroforestry:** limited
**Strengths:** Adaptation to very poor acid soils; drought tolerance; tolerant of main Centrosema diseases.
**Limitations:**
**Remarks:** combines good with *Stylosanthes guianensis* (see below). Selection of genotypes with good capability to develop nodal roots! Suits nearly all tropical life zones of St. Lucia.

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**Species name:** Desmodium heterocarpon subsp. ovalifolium.
**Origin:** Tropical southeast Asia.
**Habit:** aggressively creeping, stoloniferous, 1 m height in dense stands. Stems multi-branched, quite woody at their base
**Climate:** Humid and moist sub-humid tropical lowlands; 1200-4500 mm, preferably >2000 mm; weak drought tolerance; tolerance to waterlogging and periodic flooding.
**Soil:** Extremely well adapted to low fertility, acid soils (pH 4-7); extremely Al tolerant
**Cultivation needs:** easy to establish
**Weed potential:** Not considered to possess significant weed potential.
**Experiences in agroforestry:** yes
**Strengths:** Very well adapted to acid, infertile soils. tolerant to heavy shade.
**Limitations:** Poor drought tolerance.
**Remarks:** Suitable for heavily degraded areas at lower tropical, subtropical wet forest or rain forest life zones of St. Lucia.

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Table 1: Short List of Potential Cover Crops for Agroforestry Systems *continued*

**Species name:** *Desmodium intortum* (greenleaf desmodium, beggarlice).
**Origin:** Meso-South America (Mexiko-Brazil)
**Habit:** large trailing, scrambling, perennial; can root at nodes; strong taproot
**Climate:** 900-3000; moderate drought tolerance (less than 6 months)
**Soil:** moderate fertility, pH above 5.0; not Al-tolerant.
**Cultivation needs:** can be planted vegetatively from rooted cuttings; slow seedling growth
**Weed potential:** Possible weed of riparian vegetation due to ability to climb and shade tolerance
**Experiences in agroforestry:** yes
**Strengths:** good early and late season vigour; shade tolerant
**Limitations:** low seedling vigour; susceptibility to pests
**Remarks:** particular cultivars tested in coconut plantations; suitable for all life zones of St. Lucia. Not suitable for degraded areas.

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**Species name:** *Desmodium uncinatum* (silverleaf desmodium; Spanish tick-clover English).
**Origin:** South America (Venezuela-Argentina)
**Habit:** Stems several metres long, trail over surrounding vegetation; rooting at nodes;
**Climate:** > 1000 mm, even distribution throughout the year; persists dry seasons of max 3 months
**Soil:** High fertility, tolerant of low pH; high Al-tolerance
**Cultivation needs:** Seedling establishment initially slow
**Weed potential:** can spread into forest margins trailing over shrubs but does not climb into trees
**Experiences in agroforestry:** yes
**Strengths:** For cooler regions. Long growing season.
**Limitations:** Needs fertile soils
**Remarks:** Suitable for fertile soils in the tropical moist, subtropical wet forest to rain forest life zones, especially in higher reaches of St. Lucia

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**Species name:** *Desmodium triflorum* (creeping tick trefoil, three-flower beggarweed).
**Origin:** pantropical
**Habit:** Small prostrate, woody taproot. Strongly branched, rooting at the nodes to form a mat.
**Climate:** humid tropics and warmer subtropics, >1200 mm; leaf abszission during dry periods
**Soil:** Wide range of soil types, including acid, Al soils.
**Cultivation needs:** not yet sown commercially
**Weed potential:** low
**Experiences in agroforestry:** +
**Strengths:** Natural spread under grazing. Adapted to wide range of soils.
**Limitations:** low habit, little DM production. Difficult seed production. Restricted to higher rainfall regions.
**Remarks:**

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**Species name:** *Pueraria phaseoloides* (puero, tropical kudzu, centro grande, feuille).
**Origin:** Southern China, Taiwan, Bangladesh, Bhutan, India, Nepal, Sri Lanka, Cambodia, Laos, Myanmar, Thailand, Vietnam, Brunei, Indonesia, Philippines, Malaysia, Papua New Guinea, Solomon Islands.
**Habit:** Vigorous, deep-rooted, twining and climbing, perennial, slightly woody, rooting at the nodes
**Climate:** humid - sub-humid tropics > 1000 mm; survives dry seasons of 4-5 months
**Soil:** Wide adaptation to soil types, pH 4.0-6.5; high Al-tolerance.
**Cultivation needs:** Requires P at establishment.
**Weed potential:** In humid-tropical environments it can be an aggressive climbing /smothering plant
**Experiences in agroforestry:** yes
**Strengths:** Tolerance of soil acidity; good shade tolerance
**Limitations:** Requires medium fertility soils. Slow to establish. Low drought tolerance.
**Remarks:** mixture with one or more of the species *Calopogonium mucunoides, C. caeruleum, Centrosema molle*, and *Desmodium ovalifolium*. Suitable for the higher elevated life zones of St. Lucia (subtropical wet forest, subtropical rain forest). Naturalized in St. Lucia? If not, weed potential needs to be considered (maybe low risk due to sub-optimal climate).

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Table 1: Short List of Potential Cover Crops for Agroforestry Systems *continued*

**Species name:** *Vigna unguiculata* (cowpea, caupi, southern pea, blackeye pea, alacín, pericillo, caritas, cabecita negra, macassar bean, rope bean).
**Origin:** West Africa.
**Habit:** High variability in plant morphology of different accessions; herbaceous, prostrate, climbing, or sub-erect to erect annual, growing 15-80 cm high.
**Climate:** wide precipitation range (650-2,000 mm). Excess soil moisture harmful. Moderately tolerant of drought.
**Soil:** wide range of soils, also low-fertility soils. Wide range of pH including very acid (pH 4)
**Cultivation needs:** medium
**Weed potential:** None.
**Experiences in agroforestry:** ?
**Strengths:** Multi purpose legume; providing leaf, grain and forage. Improves soil fertility. Ease of establishment. Adaptation to a wide range of soils. Drought tolerant.
**Limitations:** Pest and disease susceptibility; host for pests of Phaseolus beans.
**Remarks:** Selection accessions which are morphologically best suited to the function as cover crop. Suitable for all life zones of St. Lucia. Utilization in annual intercropping. Not on very steep slopes.

Source: Cook et al. 2005, Barber & Navarro 1994, FAO 2008, Obi 1999, Rehm & Espig 1991, Staver 1999, Wrigley 1981.

## 4. Plants with Economic Potential

In the case of St. Lucia there are a few degrees of freedom regarding the selection of potential crop plants which might be promising constituents of agro-ecosystems. For the export based agro-economy of St. Lucia the potential economic value of a crop is as vital as its ecological value, because the definite limitation of arable land forces people to grow crops with high cash yields per area. An additional challenge is that the local food production must be improved in order to relieve St. Lucia’s trade balance which suffers from growing imports of food stuffs. Thus, at least two types of crops are to be dealt with: potential cash crops for export and food crops for domestic markets.

In order to narrow down potential candidates of crops, it first needs to be known to what capability classes of land utilization types the crops are intended for. This raises the question of the specifications, frequency and relative importance of the particular land utilization types.

In a land use compatibility assessment based on soil stability and slope steepness, Cox (2004) exemplified for the Talvan catchment of St. Lucia that only about 25% of the area is used in a sustainable way. In a modelling analysis for two other watersheds of St. Lucia the stabilizing effect of agroforestry became evident as a potential soil loss reduction by values up to 700 t $ha^{-1}$ $a^{-1}$ (Cox & Madramootoo 1998). A GIS-based analysis assessing relative suitabilities for rain-fed crop production in the Talvan watershed of St. Lucia revealed that on most sites intercropping systems mixing trees with annuals is the only option for sustainable land use (Cox 2004). These studies can be combined to the conclusion that the survival of most agrarian production units depends on the development of productive and economically attractive agroforestry systems.

In the face of climate change it might be necessary to slightly revise the land utilization type categories Cox (2004) recommended in his study, taking into account the potential positive influence of the afore mentioned soil cover crops on soil erodibility. Adapting the very valuable works of Cox (2004, 2003) and Ahmad (unpublished, cited in Cox 2004), who defined capability classes by means of soil aggregate stability of characteristic soil series and slope ranges, the following rough land use categories are the bases for the selection of crops for St. Lucia: monoculture, intercropping, high intensity agroforestry (annual crops and perennials), medium intensity agroforestry (perennials with semi-perennials and cover crops) and low intensity agroforestry (perennials and cover crops). These categories represent segments of an actually continuous theoretical gradient of disturbances through cultivation measures and of biomass harvest quotients (extracted biomass / standing biomass).

## 4.1 Crops for Monoculture and Intercropping

The agricultural sites with stable soil aggregates and moderate slopes amount to a minor percentage of 10-15% of the total arable land of St. Lucia (Cox et al. 2006). These areas are mainly cultivated with **bananas** (*Musa x paradisiaca*). One would think that the reason for this must be a high cash yield, however, when the cash yields per area are approximated based on the FAO statistics on crop yields and crop producer prices (FAOSTAT 2008), banana is by far not the most valuable crop (see Annex 9). Thus, the incentive to grow banana is obviously the income security through European import contingents. However, since the contingents will decrease further, the shrinking banana sector should focus on niches in the European banana market which promise higher revenue per unit, as for instance more exotic cultivars (with very small fruits) and/or bio-organic production.

As stated earlier, bananas are not only grown on stable soils, most of the banana plantations are currently situated on inappropriate sites with fragile soils. Thus, since the demand for banana is declining the cultivation of these high demanding crops should be continued exclusively on stable soils with moderate slopes.

According to the approximation of per area cash yields (see Annex 9), **pepper** (*Piper nigrum*) cultivation is the most profitable crop on the per area base. Nevertheless, the area under pepper cultivation is decreasing (600 ha in 2002, ca. 500 ha in 2005), probably due to the declining import of pepper by Canada and by the USA, the main importer of St. Lucian Pepper. England recently became a notable importer of St. Lucian pepper, but the gained exported quantities could not compensate for the North-American import reduction. Thus, an extension of the very profitable cultivation of pepper would necessitate stimulating the interest in other European countries to import St. Lucian pepper. On the other hand there might be a growing potential of the market for organic (bio) pepper, but this needs to be verified by respective analyses. Knowledge on the rules for bio-certification and agro-technical methods (e.g. how to combat pathogens and insects) for sound bio production would have to be amended to the local knowledge on pepper cultivation, however, this would be a general requirement when it is intended to enter the EU bio-markets with any crop.

Most of the traditional and non-traditional **staple crops** produced **for local consumption** are annuals or at least herbs, which can hardly be grown sustainably elsewhere in St. Lucia except on the stable soils with moderate slopes. Thus, the land capable for intensive monoculture which will not be used for banana or pepper production should be preferably utilized for plant cultivation for domestic consumption. Some of the staple crops cultivated in St. Lucia have been identified to have wild relatives and land races in the Caribbean subregion (FAO 1995). This offers a good chance for successful breeding programmes aiming at increasing the adaptive potential of high yielding crops to the St. Lucian environment. In the sense of the present study important staple crops with Caribbean wild relatives or land races are: *Ipomoea batatas* (**sweet potatoes**)*, Dioscorea spp.* (**yams**)*, Manihot esculenta* (**cassava**)*, Colocasia esculenta var. esculenta* (**dasheen, cocoyam**)*, Xanthosoma sagittifolium* (**tannia**)*, Colocasia esculenta var. antiquorum* (**jabba**)*, Solanum tuberosum* (**potatoes**)*, Zea mays* (**maize**)*, Sorghum spp.* (**milo**)*, Cajanus cajan* (**pigeon pea**)*, Phaseolus spp.* and *Vigna spp.* (**beans**)*, Amaranthus spp.* (**amaranth**), *Capsicum spp.* (**peppers**)*, Hibiscus esculentus* (**okra**)*, Lycopersicon spp., Lycopersicon esculentum* (**tomatoes**).

A promising plant with soil covering properties which is not named in the above short list of potential cover crops for St. Lucia is *Ipomoea batatas* (**sweet potato**). This is an outstanding crop for St. Lucia due to its high ecological, economical and nutritional value. However, sweet potato lost its former primacy among the root and tuber crops in St. Lucia in the 1990's(Annex 6) for unknown reasons. The prostrate clonal growth habit and growth vigour ("anti-erosion" properties), the comparably low soil losses through tuber harvest (Isabirye et al. 2007), and its potential as intercrop (Brook 2000) are evident advantages of sweet potato in comparison to the other starchy tuber and root crops which are grown in St. Lucia. Its potential as intercrop between annual, semi-perennial and tree crops in innovated cultivation systems in St. Lucia should lead to a renaissance of sweet potatoes which have a high nutritional value.

If one looks for additional export crops intended to be cultivated on productive and stable soil classes, the criteria for the selection should include: 1.A respective niche or potential for growth must exist in the markets of those foreign countries to which reliable trade connections exist. 2. The production must lead to high cash yields per area, even if the cultivation and management of the crop mean higher work loads. This is important because in St. Lucia arable soils are more limited than working forces. 3. The commodity should be storable, transportable and should have a high value per weight. In those cases where it is realisable, this value should partly be added by respective processing procedures, especially by preservation techniques like canning. This will have the additional advantage that the economy of St. Lucia profits from the respective value added chains.

Traditionally, spices (as pepper, see above) fulfil most of the mentioned criteria, however, the US and EU markets are more or less saturated with conventionally produced spices. The production of organic (bio-) **ginger** (*Zingiber officinale*) could be a future option. For instance the German market for non-alcoholic bio refreshment drinks – some of the products containing ginger – has increased enormously in recent years. In St. Lucia there is sufficient local knowledge on conventional ginger production: 60 metric tonnes of ginger are actually produced on 25 ha in St. Lucia (FAOSTAT 2008). However, knowledge on the requirements for a sound production of bio-ginger would have to be amended.

## 4.2 Crops for Agroforestry

A promising cash crop for monoculture on stable soils, for intercropping on moderate slopes and/or moderately stable to fragile soil aggregates, and for agroforestry on more fragile soils is the **peach palm** (*Bactris gasipaes*). It needs average temperatures above 24°C, rainfall of 1600 mm $a^{-1}$ up to 3500 mm $a^{-1}$ on well-drained soils. It can withstand relatively short dry seasons (3-4 months) if the rooted soil volume does not completely dry out (Mora-Urpi et al. 1997). Thus, peach palm is adapted to nearly all land capability classes of St. Lucia. It is a multipurpose palm tree with starchy and fat-rich edible fruits which are cooked before eating; however, the most promising economic potential is assigned to its palm hearts. The palm can be managed for permanent palm-heart production because it forms continuous offshoots harvestable after 9 to 15 months. The palm is comparably easy to establish and it grows rapidly attaining the first palm heart harvest size in 18 to 30 months. Annual yields range from 0.5 to 2 t $ha^{-1}$ and even more can be attained depending on plant densities and management practices. The prices for fresh palm hearts, which are still regarded as a delicacy even in the producing countries, are actually around 10 US$ in Brazilian supermarkets. As a fresh exotic product they will enrich the local kitchen as well as the tourist gastronomy of St. Lucia. As canned product it is probably well marketable in Europe. In the USA palm-hearts from *B. gasipaes* expanded continuously its market share (Clemet et al. 1993). In German supermarkets palm hearts from *B. gasipaes* are not yet present, but prices for canned palm hearts produced in Asia range from between 15 and 25 € per kg.

Peach palm plantations managed for palm heart production exports need relatively low amounts of nutrients from the field and leaves considerable amounts of residue and nutrients on the ground as mulch, hence improving the soil's organic matter status (Soto et al. 2005) which is crucial for chemical and physical aspects of soil fertility. Peach palm has been proven to be economically viable and ecologically sound as intensive monocultures as well as part of agroforestry systems under different environmental conditions (e.g. McGrath 2000, Soto et al. 2005). Its cultivation on St. Lucian hillsides would probably need adaptive management measures, e.g. depositing the harvest litter (mainly the palm leafs) in contours. In general the adaptability of *B. gasipaes* strains to the particular ecologic, agronomic, economic, and social conditions of St. Lucia, its marketability and the potential to install processing facilities should be studied in detail in a pilot project. However, the knowledge status on the biology and agronomy of the peach palm is rapidly growing and breeding programs are underway at different centres of competence in the tropics. This would ease the process of gathering knowledge on best practice and adaptation needs for the utilization in St. Lucia.

The production of **fresh fruits** like **guavas** (*Psidium guava*), **mangoes** (*Mangifera indica*), **mangosteens** (*Garcinia magostana*), and other not specified tropical fruits yields relatively high cash per area (Annex 9) and England is a more or less reliable importer of these fresh products. The cultivation of these fruit trees in agroforestry systems may become more attractive under bio-certification. An additional incentive to grow fruit crops on former banana plantations could arise when local juice production enterprises are established working at EU standards. Also in the case of such processed agrarian products there is evidence that the organic (bio) market sector still has growing potential in Europe. For instance, bio-juices of exotic fruits are not yet merchandised in "normal" supermarkets, where bio-orange juices but only non-bio exotic fruit juices are part of the standard assortment.

In the context of the production of fruit juices, the cultivation of the **acerola** or **Barbados cherry** (*Malpighia glabra*), a small tree native to the Lesser Antilles, could become more profitable, since the fruit sap can be used as a natural antioxidant additive in exotic bio-fruit juices due to its exorbitant high content of vitamin C (Morton 1987). The acerola tree is adapted to a wide range of precipitation regimes, so that it can potentially be grown anywhere on St. Lucia.

**Papaya** (*Carica papaya*) plays an outstanding role among the promising crops for fresh fruit production (and export) due to its excellent compatibility in mixed cropping systems accompanying e.g. peach palm and/or young *Theobroma* species (e.g. cacao). In combination with the soil cover crop *Pueraria phaseoloides* (see above such ) an agroforestry system revealed unexpected high plant productivity on degraded Amazonian upland soils (Reisdorff et al. 2002). Papaya is very suitable for the installation phase of agroforestry systems: it provides early income when the planted tree crops are juvenile; and with its characteristics as pioneer plant (in combination with an appropriate soil cover crop) it rapidly accumulates biomass and improves the growth conditions for the slower growing tree crops. On hillside experiments it has been shown that the papaya root system is highly morphoplastic: when grown on steep slope papaya plants are able to produce ascending root on the uphill side (Marler & Discekici 1997). When in St. Lucia the banana plantations will be removed from inappropriate hillside cultivations, an effective system of pioneer plants must be part of the strategy to establish agroforestry systems. Papaya plants in combination with suitable soil cover crops are a promising functional element for the early stages of agroforestry systems which are to be promptly installed.

The production of **cocoa** (*Theobroma cacao*) became less and less profitable in St. Lucia like elsewhere in the last two decades due to the decline in prices following the mass production of raw cocoa in African and Asian countries. Meanwhile, the chocolate industry in Europe is restructuring itself by focussing more and more on expensive gourmet chocolate intended to be consumed moderately in small portions. Important marketing features of these products containing high percentages of cocoa are not only distinctive aroma notes and flavours, but also proveniences of vines. Thus, the St. Lucian cocoa production could profit from this development becoming profitable in a couple of years, provided that cocoa growers successively improve their planting material e.g. by planting high quality *trinitario* or *criollo* cultivars, and conduct proper processing procedures which are capable of exploiting the entire aroma potential. Of course, such developments towards high end products must be communicated through appropriate channels to attract the interest of respective chocolate manufacturing companies.

## 5. Conclusions

The first priority for a sustainable development of the agricultural sector of St. Lucia is the establishment of agroforestry systems especially on hillsides where currently mainly banana is produced in an ecologically unbearable way. The ecological functioning of agroforestry systems towards conservation and improvement of fragile soils depends to a considerable degree on the presence of soil cover crops which add erosion-reducing properties to the system which are not provided by the tree canopy. The systematic adoption of soil covering crops has obviously not been considered yet in St. Lucia. In the present study, 13 potential cover crops have been identified to be potentially suitable for St. Lucia's with regard to the ecological service functions needed. These plants would need to be studied in trials under the pedoclimatic conditions of St. Lucia.

Two cash crops have been identified to play a potential key role with respect to both economic and ecological requirements: 1) sweet potatoes are a perfect carbohydrate source, provide good cash yields per area, they are well adapted and naturalized to St. Lucia and they provide ecological functions of soil cover crops. Efforts should be made aimed at the agricultural comeback of sweet potatoes. 2) Papaya trees are prototypes of pioneer crops under humid tropical conditions. They rapidly accumulate biomass, the roots are very morphoplastic and the precocity guarantees a quite early income in comparison to other perennial fruit crops. Papayas must be considered as functional key element for the early stages of agroforestry systems which are to be installed on former banana plantations.

The plant with the highest economic potential for export and with certain ecologically valuable features is considered to be the peach palm, which can be used for fruit production for local consumption or for the production of heart-of-palm for both local and export markets. The production of heart-of-palm would necessitate the establishment of a canning manufacture working at EU standards.

The revenue from export crops which are currently cultivated on St. Lucia could probably be increased by bio-certification (e.g. banana, pepper, ginger), by quality improvement (banana, cocoa) and/or by the establishment of a small local food industry fulfilling EU standards. Especially juices from exotic fruits might have growth potential in the bio sector of the European food market.

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FAO statistical databases; FAOSTAT: faostat.fao.org/

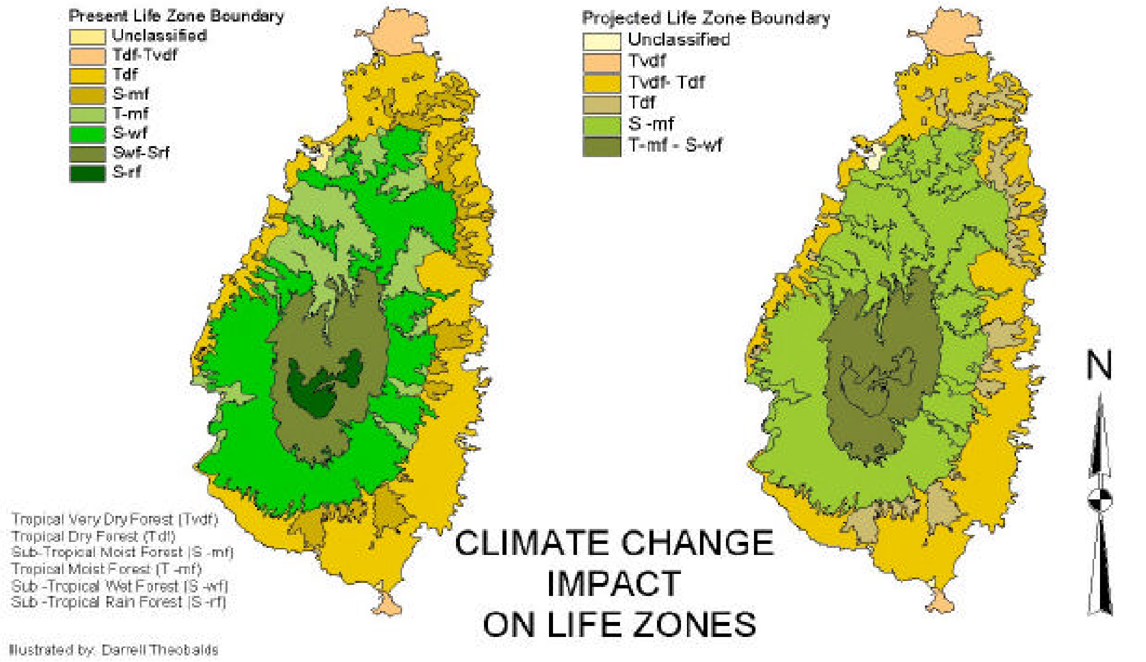
Germplasm Resources Information Network: GRIN Taxonomy for Plants www.ars-grin.gov/cgi-bin/npgs/html/taxgenform.pl?language=en

New Crop Resource Online Program, Purdue University: http://www.hort.purdue.edu/newcrop/default.html

Tropical Forages: www.tropicalforages.info/

# 7. Annexes

## Annex 1: Life Zones of St. Lucia




Source: John, L (2008). The maps show current and projected conditions by 2050 using a scenario of 20% less rainfall and increased temperatures (right). This climate scenario seems not to be very probable. However, the figure visualizes the actual life zones.

## Annex 2: Modelled rainfall for the driest and wettest month

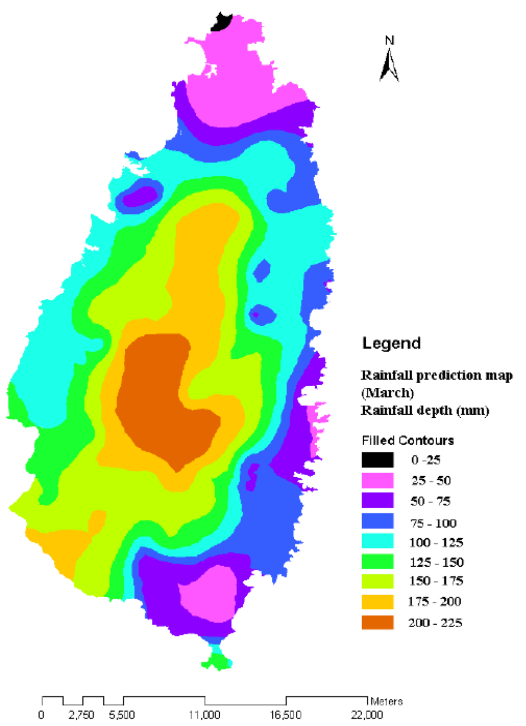



Figure 9. Rainfall prediction map of the driest month (March).

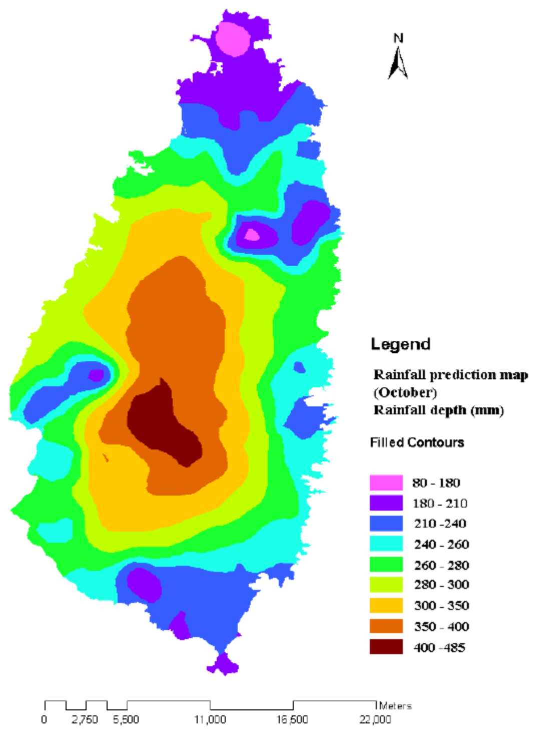



Figure 10. Rainfall prediction map of the wettest month (October).

Source: Sarangi et al. 2005 (modelled for current climate conditions)

# Annex 3: A Climate Change Scenario for St. Lucia

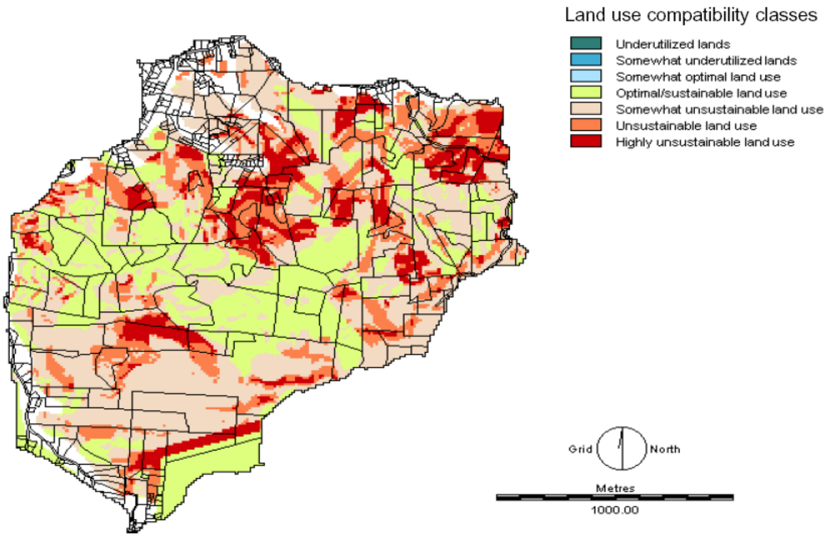
Six Climate Change Scenarios used in the National Climate Change Vulnerability and Adaptation Assessment

| Factor | Period | Scenario | Change |
|---|---|---|---|
| Annual Mean Temperature Change (oC) for 2050 | Average | Low<br>Medium<br>High | +1.71<br>+2.03<br>+5.0 |
| Annual Mean Precipitation Change (%) for 2050 | Average | Low<br>Medium<br>High | -1.3<br>-5.2<br>+20 |
| Seasonal Mean Temperature Change (oC) for 2050 | December-February | Low<br>High | 1.68<br>2.00 |
| | June-August | Low<br>High | 1.71<br>2.01 |
| Seasonal Mean Precipitation Change (%) for 2050 | December-February | Low<br>High | 3.4<br>5.9 |
| | June-August | Low<br>High | -14.4<br>-6.9 |
| Projections for Sea Level Rise (cm) for 2050 | Average | High Emissions<br>Medium Emissions<br>Low Emissions | 50<br>39<br>26 |
| Tropical Storms /Hurricanes Scenario | Average | High<br>Low | +20<br>-20 |

Source: Tulsie et al 2001

## Annex 4: Land use compatibility assessment (Talvan watershed)

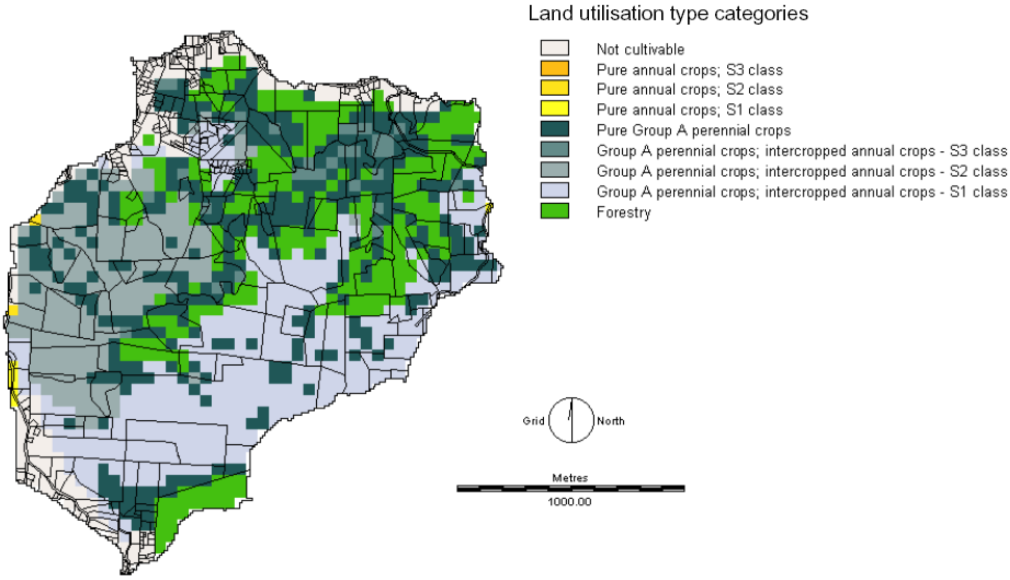
Land use compatibility assessment for the Talvan Catchment (land parcels superimposed)




Source: Cox (2004)

## Annex 5: Recommended land utilization type categories (Talvan watershed)

Agricultural and forestry land utilisation types within the Talvan catchment




Source: Cox (2004)

## Annex 6: Area harvested in the period 1985-2005

Area Harvested (ha) l Saint Lucia

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bananas | 8000 | 9310 | 10500 | 12600 | 13500 | 15000 | 12000 | 15000 | 16000 | 11000 | 14000 | 13000 | 10000 | 8000 | 8500 | 6500 | 4800 | 3600 | 4800 | 3800 | 3200 |
| Coconuts | 6250 | 6250 | 7000 | 6000 | 6500 | 7000 | 6000 | 5000 | 6000 | 4500 | 4100 | 3750 | 5000 | 2750 | 5300 | 3500 | 3100 | 3300 | 3500 | 2835 | 2506 |
| Pepper (Piper spp.) | 8 | 50 | 100 | 140 | 200 | 280 | 160 | 250 | 160 | 220 | 400 | 250 | 260 | 330 | 330 | 330 | 460 | 600 | 460 | 509 | 520 |
| Cassava | 280 | 280 | 290 | 290 | 290 | 300 | 300 | 310 | 310 | 315 | 315 | 320 | 320 | 320 | 330 | 330 | 330 | 330 | 330 | 336 | 339 |
| Plantains | 450 | 490 | 490 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 380 | 290 | 370 | 330 | 200 | 200 | 200 | 200 | 200 | 330 | 200 |
| Spices, nec | 260 | 400 | 220 | 220 | 220 | 220 | 230 | 230 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 230 | 220 | 230 | 220 | |
| Grapefruit (inc. pomelos) | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 52 | 52 | 60 | 137 | 103 | 285 | 170 | 170 | 330 | 350 | 386 | 250 | 200 | 130 |
| Yams | 970 | 970 | 970 | 980 | 1000 | 1000 | 1050 | 1050 | 1100 | 1100 | 1150 | 1150 | 1200 | 1000 | 120 | 120 | 120 | 200 | 180 | 150 | 130 |
| Vegetables, nec | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 130 | 130 | 135 | 135 | 140 | 140 | 140 | 140 | 140 | 140 | |
| Guavas, mangoes, | 3400 | 3400 | 3400 | 3400 | 3400 | 3400 | 3450 | 3450 | 3450 | 3500 | 3500 | 3550 | 3500 | 3600 | 120 | 135 | 140 | 140 | 110 | 85 | 75 |
| Nutmeg, mace and cardamoms | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 65 | 65 | 65 | 70 | 70 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 79 | 81 |
| Taro (cocoyam) | 55 | 56 | 56 | 57 | 57 | 58 | 58 | 60 | 60 | 62 | 62 | 62 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | |
| Oranges | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 100 | 100 | 90 | 76 | 78 | 185 | 90 | 80 | 130 | 95 | 55 | 55 | 50 | 50 |
| Sweet potatoes | 210 | 200 | 190 | 180 | 170 | 170 | 150 | 120 | 90 | 70 | 50 | 55 | 100 | 34 | 50 | 90 | 70 | 85 | 60 | 50 | 22 |
| Cocoa beans | 120 | 120 | 120 | 120 | 120 | 60 | 70 | 80 | 85 | 70 | 40 | 40 | 40 | 30 | 35 | 30 | 40 | 40 | 40 | 40 | 40 |
| Lemons and limes | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 30 | 30 | 25 | 28 | 20 | 57 | 30 | 15 | 35 | 35 | 30 | 35 | 40 | 45 |
| Avocados | 105 | 105 | 105 | 90 | 80 | 80 | 70 | 65 | 60 | 60 | 40 | 79 | 66 | 30 | 50 | 60 | 55 | 45 | 40 | 35 | 30 |
| Yautia (cocoyam) | 23 | 23 | 24 | 24 | 25 | 25 | 26 | 26 | 27 | 27 | 28 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | |
| Ginger | 45 | 45 | 40 | 25 | 25 | 25 | 25 | 20 | 20 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 26 |
| Pulses, Nec | 20 | 20 | 20 | 25 | 25 | 25 | 30 | 30 | 30 | 25 | 25 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | |
| Coffee, green | 18 | 19 | 20 | 20 | 0 | | | | | | | | | | | | | | | | |
| Sum | 20591 | 24101 | 23922 | 25048 | 26489 | 28520 | 24496 | 26563 | 28484 | 22059 | 24776 | 23242 | 21948 | 17279 | 15870 | 12360 | 10375 | 9581 | 10640 | 9034 | 7394 |

Source: FOASTAT l FAO Statistics Division 2008 l 5 Feburary 2005

## Annex 7: Crop yields per area in the period 1985-2005

Yield per hectar (kg/ha) | Saint Lucia
commodity

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avocados | 4476 | 4571 | 4762 | 5667 | 6500 | 6250 | 6429 | 6154 | 5833 | 5000 | 6250 | 6203 | 6212 | 7333 | 6620 | 6600 | 6364 | 6667 | 7000 | 7143 | 7167 |
| Bananas | 13262 | 15154 | 10852 | 13338 | 10741 | 10667 | 10667 | 10533 | 10000 | 10455 | 10000 | 10000 | 10000 | 10000 | 10000 | 10462 | 10417 | 10418 | 10417 | 10526 | 10250 |
| Cassava | 3321 | 3321 | 3241 | 3241 | 3241 | 3167 | 3167 | 3097 | 3097 | 3079 | 3079 | 3063 | 3063 | 3063 | 3030 | 3030 | 3030 | 3030 | 3030 | 3006 | 2997 |
| Cocoa beans | 833 | 833 | 833 | 833 | 833 | 800 | 771 | 750 | 812 | 729 | 700 | 800 | 750 | 767 | 743 | 767 | 750 | 750 | 750 | 750 | 725 |
| Coconuts | 3840 | 4000 | 4000 | 3833 | 4000 | 4286 | 4167 | 4000 | 4000 | 4000 | 4024 | 4000 | 4400 | 4000 | 4000 | 4000 | 4032 | 4000 | 4000 | 3943 | 3896 |
| Coffee, green | 1000 | 1000 | 1000 | 1000 | | | | | | | | | | | | | | | | | |
| Fruit, nec | 5922 | 6168 | 6396 | 6577 | 6847 | 6207 | 6667 | 6639 | 6475 | 6613 | 6640 | 6614 | 6641 | 6641 | 6692 | 6692 | 6692 | 6667 | 6692 | 6692 | 6692 |
| Ginger | 2733 | 3400 | 2625 | 2320 | 2000 | 2800 | 2400 | 2350 | 2500 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2308 |
| Grapefruit (inc. pomelos) | 6000 | 6222 | 6444 | 6667 | 6667 | 6889 | 7778 | 7692 | 8269 | 7833 | 8628 | 8621 | 9874 | 8194 | 7482 | 7818 | 7714 | 7702 | 8000 | 7500 | 7831 |
| Guavas, mangoes, | 7647 | 7647 | 7353 | 7353 | 7059 | 7059 | 7246 | 7391 | 7536 | 7571 | 7714 | 7746 | 7571 | 7500 | 8750 | 8000 | 7786 | 7829 | 7273 | 7647 | 7747 |
| Lemons and limes | 5946 | 6216 | 6486 | 6757 | 7027 | 7297 | 6486 | 6667 | 6000 | 6400 | 6179 | 5800 | 6211 | 6100 | 11533 | 10914 | 10000 | 10000 | 11429 | 11250 | 11378 |
| Nutmeg, mace and cardamoms | 250 | 250 | 283 | 283 | 300 | 300 | 333 | 338 | 308 | 338 | 357 | 357 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 342 | 333 |
| Oranges | 2727 | 2818 | 2818 | 2909 | 3000 | 3091 | 3636 | 5000 | 6000 | 7222 | 8684 | 8641 | 8632 | 7833 | 11100 | 10885 | 10526 | 10945 | 10909 | 11000 | 10240 |
| Pepper (Piper spp.) | 625 | 600 | 600 | 607 | 650 | 714 | 625 | 760 | 625 | 727 | 658 | 784 | 769 | 758 | 758 | 758 | 761 | 750 | 761 | 764 | 769 |
| Plantains | 4000 | 3673 | 3673 | 3800 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 | 3947 | 4041 | 4057 | 3927 | 3550 | 3450 | 3500 | 3600 | 3500 | 2121 | 3575 |
| Pulses, Nec | 2500 | 2500 | 2500 | 2200 | 2200 | 2200 | 2000 | 2000 | 2000 | 2200 | 2200 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Roots and Tubers Nec | 4263 | 4271 | 4271 | 4278 | 4278 | 4286 | 4286 | 4242 | 4242 | 4121 | 4100 | 4100 | 4200 | 4000 | 3909 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 |
| Spices, nec | 500 | 725 | 591 | 591 | 591 | 591 | 609 | 609 | 591 | 591 | 591 | 591 | 591 | 591 | 591 | 591 | 609 | 591 | 609 | 591 | 591 |
| Sweet potatoes | 7000 | 7350 | 7789 | 8222 | 8765 | 8765 | 8667 | 9167 | 10000 | 10000 | 10140 | 10145 | 10390 | 11147 | 9600 | 9289 | 9286 | 9153 | 9167 | 9400 | 9273 |
| Taro (cocoyam) | 5000 | 5000 | 5000 | 5088 | 5263 | 5172 | 5172 | 5083 | 5167 | 5161 | 5161 | 5161 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 |
| Vegetables, nec | 6880 | 7040 | 7200 | 7360 | 7360 | 7440 | 7200 | 7200 | 7440 | 7360 | 7231 | 7231 | 7037 | 7037 | 7143 | 7143 | 7143 | 7143 | 7143 | 7143 | 7143 |
| Yams | 3918 | 3918 | 3918 | 3929 | 4000 | 4000 | 3905 | 3905 | 3818 | 3909 | 3739 | 3739 | 3750 | 3800 | 3750 | 3750 | 3750 | 3445 | 3333 | 3333 | 3231 |
| Yautia (cocoyam) | 5217 | 5217 | 5417 | 5417 | 5600 | 5600 | 5769 | 5769 | 5926 | 5926 | 6071 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 |

Source: FOASTAT | FAO Statistics Division 2008 | 5 Feburary 2005

## Annex 8: Producer prices for the period 1985-2005

Producer Price (US$/tonne) | Saint Lucia

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avocados | 983 | 980 | 1007 | 1004 | 1122 | 889 | 1000 | 1126 | 889 | 748 | 893 | 900 | 1604 | 1917 | 2145 |
| Bananas | 425 | 428 | 426 | 474 | 459 | 444 | 444 | 463 | 493 | 159 | 448 | 448 | 463 | 620 | 606 |
| Cassava | 1221 | 1235 | 1231 | 1251 | 1280 | 1270 | 1269 | 1292 | 1314 | 1344 | 1362 | 1379 | 1388 | 1439 | 1455 |
| Cocoa beans | 2399 | 2440 | 2444 | 2444 | 2444 | 2444 | 2444 | 2444 | 2444 | 2444 | 2444 | 2444 | 2444 | 2521 | 2545 |
| Coconuts | 391 | 393 | 383 | 418 | 427 | 453 | 462 | 331 | 349 | 279 | 235 | 244 | 436 | 498 | 563 |
| Ginger | 1709 | 1696 | 1600 | 1659 | 2004 | 2341 | 2263 | 1811 | 1581 | 1522 | 1296 | 1674 | 2622 | 3015 | 3424 |
| Goat meat | 3957 | 4004 | 3990 | 4055 | 4148 | 4116 | 4114 | 4188 | 4260 | 4356 | 4415 | 4469 | 4498 | 4664 | 4718 |
| Grapefruit (inc. pomelos) | 437 | 449 | 448 | 430 | 422 | 463 | 385 | 437 | 459 | 374 | 352 | 407 | 711 | 834 | 951 |
| Guavas, mangoes, mangosteens | 592 | 598 | 619 | 522 | 652 | 537 | 567 | 715 | 667 | 644 | 544 | 715 | 1281 | 1525 | 1787 |
| Lemons and limes | 678 | 710 | 722 | 785 | 619 | 681 | 607 | 626 | 756 | 526 | 493 | 563 | 952 | 1104 | 1248 |
| Nutmeg, mace and cardamoms | 3635 | 3642 | 3559 | 3444 | 4052 | 4181 | 4389 | 4533 | 4644 | 5004 | 4822 | 4367 | 4396 | 4443 | 4434 |
| Oranges | 687 | 705 | 707 | 678 | 674 | 700 | 615 | 707 | 611 | 544 | 619 | 611 | 1081 | 1277 | 1424 |
| Pepper (Piper spp.) | 40594 | 41070 | 40932 | 41597 | 42553 | 42226 | 42197 | 42958 | 43702 | 44683 | 45287 | 45839 | 46142 | 47843 | 48394 |
| Plantains | 431 | 420 | 430 | 478 | 552 | 407 | 419 | 459 | 433 | 426 | 585 | 485 | 770 | 896 | 950 |
| Pulses | 6303 | 6377 | 6356 | 6459 | 6607 | 6557 | 6552 | 6670 | 6786 | 6938 | 7032 | 7118 | 7165 | 7429 | 7515 |
| Roots and Tubers | 1038 | 1034 | 1033 | 1089 | 1178 | 1061 | 1009 | 1041 | 1156 | 1093 | 1159 | 915 | 1528 | 1708 | 1833 |
| Spices | 8183 | 8279 | 8251 | 8385 | 8578 | 8512 | 8506 | 8659 | 8810 | 9007 | 9129 | 9240 | 9301 | 9644 | 9755 |
| Sweet potatoes | 915 | 914 | 915 | 1059 | 1033 | 933 | 915 | 1041 | 1159 | 959 | 1078 | 748 | 1237 | 1373 | 1450 |
| Taro (cocoyam) | 726 | 703 | 711 | 800 | 967 | 722 | 707 | 800 | 863 | 837 | 796 | 707 | 1122 | 1237 | 1334 |
| Yams | 1269 | 1279 | 1304 | 1270 | 1356 | 1189 | 1104 | 1041 | 1181 | 1226 | 1289 | 1267 | 1819 | 2018 | 2154 |

Source: FOASTAT | FAO Statistics Division 2008 | 26 Feburary 2005

# Annex 9: Approximated cash yields per area in the period 1991-2005

| Cash Yield per ha ($ per ha) | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | MV | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pepper (Piper spp.) | 25371 | 31213 | 25583 | 30252 | 27979 | 33105 | 32460 | 32544 | 33108 | 33851 | 34458 | 34379 | 35108 | 36563 | 37226 | 32213 | 3587 |
| Pulses, Nec | 12607 | 12754 | 12712 | 14210 | 14536 | 13113 | 13104 | 13341 | 13572 | 13876 | 14064 | 14236 | 14330 | 14858 | 15029 | 13756 | 792 |
| Vegetables, nec | 9645 | 9717 | 10278 | 11149 | 10431 | 8918 | 9735 | 10543 | 10265 | 9907 | 8532 | 10251 | 13095 | 14250 | 15399 | 10808 | 1939 |
| Sweet potatoes | 7928 | 8376 | 9148 | 10593 | 10478 | 9469 | 9505 | 11601 | 11129 | 8910 | 10008 | 6848 | 11340 | 12907 | 13442 | 10112 | 1805 |
| Yautia (cocoyam) | 6788 | 6793 | 6826 | 6628 | 8028 | 8067 | 6822 | 7289 | 6911 | 7356 | 7444 | 6489 | 11489 | 13103 | 14424 | 8297 | 2542 |
| Avocados | 6321 | 6028 | 5877 | 5019 | 7014 | 5513 | 6212 | 8257 | 5884 | 4938 | 5680 | 6000 | 11226 | 13693 | 15370 | 7535 | 3248 |
| Fruit, nec | 6591 | 6702 | 6731 | 6471 | 6445 | 5884 | 6207 | 6664 | 6075 | 5548 | 5860 | 6082 | 9676 | 11082 | 12164 | 7212 | 2032 |
| Oranges | 2500 | 3524 | 4244 | 4895 | 5854 | 6049 | 5307 | 5541 | 6783 | 5926 | 6511 | 6689 | 11798 | 14043 | 14578 | 6949 | 3617 |
| Lemons and limes | 4399 | 4731 | 4333 | 5025 | 3822 | 3953 | 3772 | 3818 | 8714 | 5740 | 4926 | 5630 | 10878 | 12420 | 14198 | 6424 | 3431 |
| Guavas, mangoes, mangosteens | 4289 | 4418 | 4661 | 3954 | 5029 | 4160 | 4291 | 5361 | 5833 | 5156 | 4239 | 5596 | 9320 | 11660 | 13844 | 6121 | 3017 |
| Spices, nec | 4981 | 5039 | 4876 | 4955 | 5069 | 5030 | 5026 | 5117 | 5206 | 5322 | 5557 | 5460 | 5662 | 5699 | 5764 | 5251 | 302 |
| Yams | 4955 | 4995 | 4978 | 4966 | 5069 | 4445 | 4139 | 3955 | 4431 | 4597 | 4833 | 4364 | 6062 | 6727 | 6961 | 5032 | 887 |
| Roots and Tubers Nec | 4448 | 4389 | 4384 | 4487 | 4829 | 4351 | 4239 | 4163 | 4517 | 4370 | 4637 | 3659 | 6111 | 6833 | 7334 | 4850 | 1046 |
| Ginger | 4100 | 3986 | 4000 | 3982 | 4809 | 5618 | 5431 | 4347 | 3796 | 3653 | 3111 | 4018 | 6293 | 7236 | 7900 | 4819 | 1396 |
| Bananas | 4531 | 4506 | 4259 | 4956 | 4593 | 4444 | 4444 | 4630 | 4926 | 1666 | 4668 | 4669 | 4823 | 6527 | 6213 | 4657 | 1047 |
| Taro (cocoyam) | 3757 | 3575 | 3674 | 4129 | 4989 | 3728 | 3537 | 4000 | 4315 | 4185 | 3982 | 3537 | 5611 | 6186 | 6668 | 4392 | 1006 |
| Grapefruit (inc. pomelos) | 3399 | 3456 | 3706 | 3365 | 3643 | 3991 | 3803 | 3581 | 3436 | 2925 | 2714 | 3138 | 5689 | 6251 | 7443 | 4036 | 1339 |
| Cassava | 3867 | 3825 | 3812 | 3853 | 3942 | 3889 | 3887 | 3957 | 3983 | 4073 | 4128 | 4178 | 4205 | 4325 | 4362 | 4019 | 182 |
| Plantains | 1726 | 1681 | 1719 | 1911 | 2178 | 1646 | 1698 | 1804 | 1538 | 1469 | 2048 | 1747 | 2696 | 1901 | 3397 | 1944 | 501 |
| Cocoa beans | 1850 | 1830 | 1984 | 1781 | 1711 | 1956 | 1833 | 1874 | 1816 | 1874 | 1833 | 1833 | 1833 | 1891 | 1845 | 1850 | 65 |
| Coconuts | 1631 | 1573 | 1533 | 1673 | 1719 | 1812 | 2032 | 1324 | 1394 | 1116 | 948 | 976 | 1742 | 1962 | 2192 | 1575 | 370 |
| Nutmeg, mace and cardamoms | 1212 | 1233 | 1095 | 1166 | 1447 | 1493 | 1463 | 1511 | 1548 | 1668 | 1607 | 1456 | 1465 | 1518 | 1478 | 1424 | 168 |

Source: Calculations based on FAO data for St. Lucia (FOASTAT 2008): producer proces per weight of commodity X yield per area = cash yield per area

The cash yields per area have been approximated on the basis of the FAO data on St. Lucia's agrarian commodities (FAOSTAT 2008). For each commodity the yields per area (see annex 7) were multiplied with the producer prices (see annex 8). This estimation gives not exact data on the revenue per area but an orientation and ranking of the gross cash yields on an area base. Labour and other costs are not considered.

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